ON THE MAGNETIC FIELD, AND ENTROPY INCREASE, IN A MACHIAN UNIVERSE

Marcelo Samuel Berman[1]

[1]*Editora Albert Einstein Ltda - Av. Candido Hartmann, 575 - # 17 and 80730-440 - Curitiba - PR - Brazil*

(Dated: (v.2) 19 November, 2006)

Abstract

By means of the experimental result on the present equipartition between background microwave radiation energy and that of the interstellar magnetic field, and by advancing a Machian relation for the magnetic field, which, differently than in other authors' papers, is valid for the entire spanlife of the Universe, implying that the magnetic field depends on the inverse radius of the Universe, we obtain a general formula such that B depends on R^{-1}.Our estimate for Planck's magnetic field is 10^{-3} times the Sabbata and Sivaram's one. It is shown that the energy densities involved in the above problem are dependent on R^{-2} . For radiation, this implies, as we show, that the total entropy of the Universe is increasing with expansion. In particular we show that $R \propto T^{-2}$, where T is the absolute temperature, and the entropy is proportional to $R^{\frac{3}{2}}$.

Keywords: Cosmology; Einstein; Brans-Dicke; Cosmological term; Planck's Universe; Mach; Magnetic Field; Entropy; Radiation.

PACS: 04.20.-q ; 04.20.Jb ; 98.80.-k ; 98.80.Jk

ON THE MAGNETIC FIELD, AND ENTROPY INCREASE, IN A MACHIAN UNIVERSE

Marcelo Samuel Berman

In two recent chapters of edited books (Berman, 2006; 2006a) it was proposed a new interpretation for Brans-Dicke relation, which, instead of being an aproximate relation only valid for the present Universe, should be interpreted as meaning that the mass M , of the causally related Universe, is directly proportional to the radius R , in the entire life of the Universe. In the same references, it is shown that, the new interpretation of Brans-Dicke relation, along with the hypothesis that the cosmological "constant" varies with R^{-2} , arise from the imposition that the total energy of the Universe, is zero-valued. Sabbata and Sivaram(1994), have shown that, in analogy with Brans-Dicke aproximate relation, one could state another similar one for the spin of the Universe L . Again, Berman(2006b), extending his conjectures on the zero-total energy of the Universe, and including in the total energy, a term representing the rotational energy, derived Sabbata and Sivaram(1994) aproximate relation, as an exact formula, indicating that L varied with R^2 during all times. In all cases, Berman has made the hypothesis, that the fraction of each kind of energy participation, did not vary with time, when taken as fractions of Mc^2 . This implies, that if the Universe is Λ – driven today, it was also along all periods of time. This "explains" that the result obtained by A. Riess and colaborators, described by the international media, as of November, 2006, only means that our Universe is indeed, a zero – total – energy entity.

We now extend Berman's hypotheses, while keeping a new term which contributes to the total energy of the Universe, dictated by the magnetic field. The fraction of magnetic energy participation to the total energy, is nevertheless kept in a 10^{-3} orders of magnitude, because we take for granted that the observed equipartition between the microwave background radiation, and magnetic field energies, for interstellar media, point out to a similar fraction in the magnetic field of the Universe. We impose that such fraction endures for the entire history of the Universe; in fact, this means that we adjust our Machian relation for the magnetic field, in order that its present value should be around 10^{-6} Gauss.

As the fractions of energy, of any kind, in the Machian Universe, according to our theory, are to be maintained, we take for granted, that any kind of energy's density, varies with R^{-2} , as has been shown, for the total energy density, by Berman(2006; 2006a) and Berman and Marinho Jr(2001). For each type of energy, we would have a constant fraction of the total energy, i.e., constant in time. For the total energy density, we would have:

$$\rho = \frac{M}{\frac{4}{3}\pi R^3} \quad . \tag{1}$$

From Brans-Dicke relation, as modified by Berman, we have:

$$\frac{GM}{Rc^2} = \gamma = \quad \text{constant} \ \sim 1 \quad . \tag{2}$$

From (1) and (2), we obtain the desired dependence, $\rho \propto R^{-2}$.

The energy density associated with a magnetic field B is given by:

$$\rho_B = \frac{B^2}{8\pi} \quad . \tag{3}$$

In mass units, we have to divide the second member of (3) by c^2 . The total energy fraction for the magnetic field, relative to Mc^2 would be given by:

$$\left[\frac{4}{3}\pi R^3\right] \left[\frac{B^2}{8\pi c^2}\right] \left[Mc^2\right]^{-1} = \gamma_B \cong 10^{-6} \quad . \tag{4}$$

We then find that $B \propto R^{-1}$ because, in fact, from (4) we have:

$$B^2 = 12 \ \ c^4 \ \gamma \ \gamma_B \ G^{-1} R^{-2} \quad . \tag{5}$$

We then find, for the present Universe, with $R \cong 10^{28}$ cm, $B \cong 10^{-6}$ Gauss .

For Planck's Universe, we would have, with $R_{Pl} \cong 10^{-33}$ cm,

$$B_{Pl} = B \left[\frac{R}{R_{Pl}}\right] \cong 10^{55} \text{ Gauss.}$$

This last value is larger than the maximum limit for the magnetic field not to provoke instabilities in the vacuum, according to a recent analysis made through Quantum Electrodynamics theory (QED), by Shabad and Usov(2006). That being the case, we can imagine this fact as causing the eruption of the inflationary phase, immediatly after Planck's time.

We remark that Sabbata and Sivaram(1994) obtained, in other context, for the Planck's magnetic field, the value 10^{58} Gauss, which is larger than in our estimate.

Though we have derived the dependency of the magnetic field with R^{-1}, from the zero-total energy conjecture, in a Machian Universe, (see relation 4 above), this is also obtained from the energy density dependence on R^{-2}, which is also derived from the above conjecture, as also has been considered above, for any kind of particular energy, during the lifespan of the Universe.

It has been argued by an annonymous referee, that there would be one kind of energy density, that would not obey the R^{-2} - dependence, namely, the radiation one. Though the radiation energy density obeys the well-known black body law

$$\rho_R = aT^4 \qquad (a = \text{constant}) \quad , \tag{6}$$

where T stands for the absolute temperature, we must first agree on the dependence between R and T. In standard Cosmology, it is accepted as a general rule, that the total entropy of the Universe is constant in time; then, it is easily shown that

$$RT = \text{constant.} \tag{7}$$

Notwithstanding, this hypothesis for the entropy has been troubled by several observations, which run from the verification that photons' production in the Universe, must be accompanied by an increasing value for the entropy of the Universe. Weinberg (1972), has long ago warned that the perfect fluid hypothesis concerning the non-dissipative fluid, is problematic. He even advanced the idea of a viscous fluid. It is well-known that a perfect fluid is isentropic.

If the Machian perspective is taken into account, we should have:

$$\rho_R = \beta R^{-2} \qquad (\beta = \text{constant}) \quad . \tag{8}$$

A comparison between (6) and (8), makes us believe that $R \propto T^{-2}$; this relation is obtainable from the zero-total energy conjecture for the Universe. If we write the energy as

represented by an inertial term (Mc^2) minus the potential energy $(\frac{GM^2}{2R})$ plus the radiation energy $(\frac{4}{3}\pi R^3 \rho_R)$, and equate the result to zero, we find:

$$\frac{GM}{c^2 R} - \frac{4\pi R^3}{3Mc^2}\rho_R \cong 1 \qquad . \qquad (9)$$

From Brans-Dicke original relation(Brans and Dicke, 1961), we find relation (2). This suggests that we also should have the following relation:

$$\frac{4\pi R^3 \rho_R}{3Mc^2} = \gamma_R = \text{constant} \sim 1 \qquad . \qquad (10)$$

From the above, we obtain:

$$\frac{aGT^4R^2}{c^4} = \text{ constant} \qquad . \qquad (11)$$

We conclude that $R \propto T^{-2}$ as we believed above. This dependence was studied earlier for non-relativistic decoupled matter (Kolb and Turner, 1990).

We now check the total entropy of this (Machian) Universe:

$$S \propto sR^3 \propto \frac{\rho_R}{T} R^3 \propto T^3 R^3 \propto R^{\frac{3}{2}} \qquad . \qquad (12)$$

In the above, S and s stand respectivelly for the total entropy, and the entropy density; from thermodynamics, $S = \frac{E_R}{T}$, where E_R stands for the total radiational energy.

From (12), we have the result that should had been obvious to cosmologists long ago: total entropy increases with the expanding Universe.

The above result is approximately similar to the one of black hole thermodynamics: the entropy, in this case, is proportional to the surface area of the event horizon, $4\pi R^2$. Here R stands for Schwarzschild's radius, $2GM$. Notice that in the expanding Universe, the event horizon radius also should grow with time, due to the isotropy and homogeneity of the Universe, which causes increasing entropy for black holes, too. This is a Classical Physics effect, independent of Quantum theory.

The perfect fluid hypothesis, for the Universe, is here challenged by Mach's Principle. We conclude that, because we did not restrict ourselves, to a specific gravitational theory, like General Relativity, Brans-Dicke or other alternative one theories, any theory can be Machian, provided that the above framework is accomodated in those theories.

Acknowledgements

The author gratefuly thanks his intellectual mentors, Fernando de Mello Gomide and M. M. Som, and is also grateful for the encouragement by Albert, Paula and Geni, and by Marcelo Guimarães, Nelson Suga, Mauro Tonasse, Antonio Teixeira and Herman J. M. Cuesta. Comments by Dimi Chalakov, on several papers of mine, are highly praised.

References

Berman,M.S. (2006) - *Energy of Black Holes and Hawking's Universe* - in *Trends in Black Hole Research,* ed. by Paul Kreitler, Nova Science, New York.

Berman,M.S. (2006 a) - *Energy, Brief History of Black Holes, and Hawking's Universe*, in *New Developments in Black Hole Research,* ed. by Paul Kreitler, Nova Science, New York.

Berman,M.S. (2006 b) - *On the Machian Properties of the Universe* - submitted. (Also posted in Los Alamos archives, http://arxiv.org/abs/physics/0610003).

Brans, C.; Dicke, R.H. (1961) - Physical Review, **124**, 925.

Kolb, E.W.; Turner, M.S. (1990) - *The Early Universe*, Addison-Wesley, N.Y.

Sabbata, V.de; Sivaram, C. (1994) - *Spin and Torsion in Gravitation* - World Scientific, Singapore.

Shabad, A.E.; Usov, V.V. (2006) - Phys. Rev. Lett. **96**, 180401.

Weinberg, S. (1972) - *Gravitation and Cosmology*, Wiley, New York.